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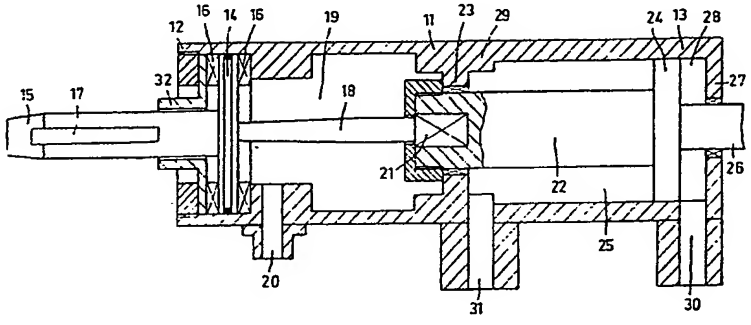
(54) Method of and apparatus for enlarging a tube

(57) A method of enlarging a tube to be pressure fitted in a flange plate comprises so pressing a conical roller mandrel (18) between rollers carried by a rotatable body (15) as to splay the rollers radially apart. The mandrel (18) is operatively connected with a pneumatic or hydraulic piston-cylinder unit (24, 25) operable by a pressure medium. A control device controls the application of pressure medium in dependence on the reaction force acting on the mandrel (18) during deformation of the tube.

Fig.1



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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

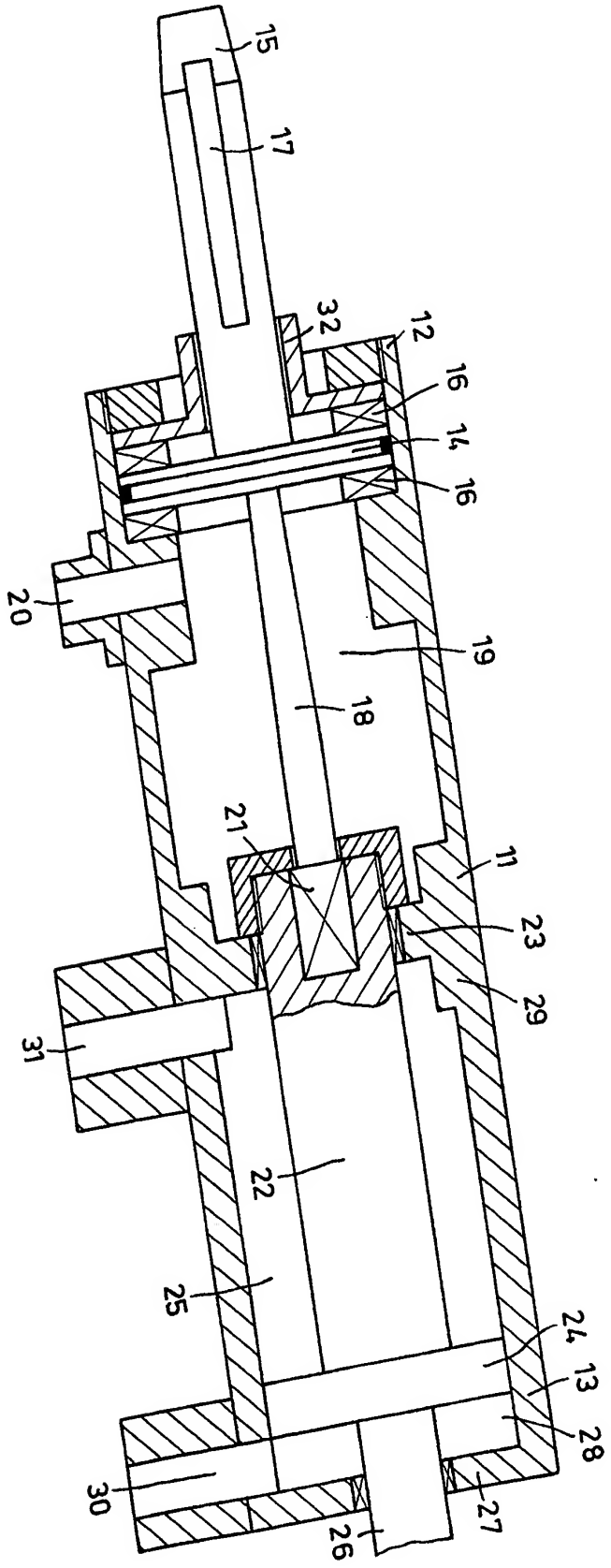

Fig.1

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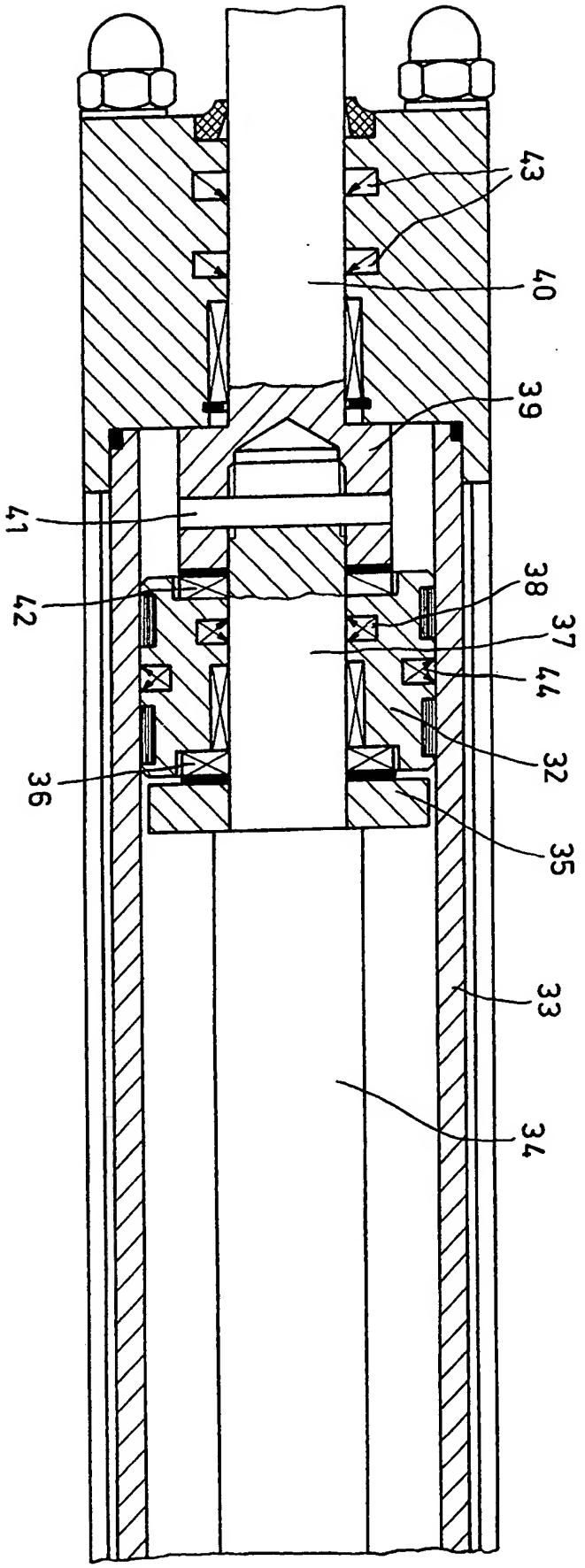

Fig.2

SPECIFICATION

Method of and apparatus for enlarging tubes

The present invention relates to a method of and apparatus for enlarging a tube for pressure fitting in an opening in a support, for example a flange plate.

It is known to pressure fit tubes in openings in supports by enlarging the tubes by means of rollers acting on the tube internal wall, the rollers being radially splayed apart by a tapering mandrel. However, it has proved with thin-walled tubes, even with the use of very accurate checking devices, that the tubes cannot be expanded for tight fitting as the three-point contact with the mandrel by three such rollers (or, for example, five-point contact in the case of five such rollers) cannot be cancelled. Consequently, a rolling circle is not provided. Thus, in automatic tube rolling with thin-walled tubes, the tubes do not bear uniformly against the rims of the openings. A similar problem arises in rolling with apparatus in which the rollers extend parallel to the tube axis and the rollers are advanced by means of a thread after non-slip interengagement of the tube and support. In both cases, the advance of the rollers in the tube cannot be readily adapted to the requirements, or at least not without considerable cost and complication. In automatic rolling apparatus, the advance is determined by the angle at which the rollers extend relative to the tube axis.

There is accordingly a need for a tube enlarging method and apparatus by which a cylindrical rounding is provided at least at the start and/or end of the rolling location. Not only the advance of the mandrel should be variable during the spreading of the rollers, but it should also be possible to adapt the advance of the rollers themselves to the conditions so that an optimum advance can be set in dependence on the wall thickness, the material and the diameter of the tubes.

According to one aspect of the present invention there is provided a method of enlarging a tube for pressure fitting in an opening in a support, comprising the steps of introducing into such tube a plurality of rollers carried by a rotatable body, applying a pressure medium to piston-cylinder displacing means to effect movement of an operatively associated conically tapering mandrel between the rollers to spread the rollers radially apart, and controlling the application of the pressure medium in dependence on the reaction force acting on the mandrel during rotation of the body to deform the tube by the rollers.

Advantageously, the pressure of the pressure medium applied to the displacing means is equal to the reaction force, or equal to a force drawing the mandrel between the rollers, for a settable period of time before and/or after enlargement of the tube to the point of slip-free engagement with the support.

According to another aspect of the invention there is provided apparatus for enlarging a tube for pressure fitting in an opening in a support, the apparatus comprising a plurality of tube-engaging rollers carried by a rotatable body, a conically tapering mandrel movable between the rollers to spread the rollers radially apart, and displacing means comprising a cylinder and a piston arranged in the cylinder and connected to the mandrel, the piston being so displaceable by a pressure medium applied to the cylinder as to effect said movement of the mandrel, and control means for controlling the application of the pressure medium in dependence on the reaction force acting on the mandrel during rotation of the body to deform the tube.

A method exemplifying the present invention and apparatus embodying the invention have the advantage that the advance of the mandrel between the rollers and thereby the spreading of the rollers can be controlled in dependence on the reaction force. This means that the mandrel can be advanced very rapidly when the rollers do not yet lie against the inside wall of the tube. The start of the enlargement process after introduction of the rollers into the tube can thus take place very rapidly. When a reaction force arises during the deformation process, the pressure on the throughflow quantity of the pressure medium can then be controlled so that a slower or quicker deformation speed results, i.e. the enlargement of the tube takes place more slowly or more rapidly according to the setting of the control. This is important because, with the currently employed tubes of high grade material and small wall thicknesses, consideration of these factors in the enlargement of the tube to the slip-free point is absolutely necessary in order to obtain the best possible fit. Tight fitting of the tube in the support is essential in, for example, construction of heat exchangers for reactors so that optimum safety of the tubes is provided and the tubes will not be prematurely and unpredictably destroyed, for example, through intercrystalline corrosion or tension cracking.

In using an automatic apparatus in which rollers extend obliquely to the axis of the rotatable body, after the introduction of the rollers into the tube the mandrel may be initially advanced by means of a large quantity of the pressure medium until the rollers are spread apart by such an extent that they bear against the inside wall of the tube. The rolling mandrel is then drawn between the rollers by the rollers themselves while simultaneously the rollers run further forward in the tube. If a smaller pressure is now applied to the displacing means, the mandrel will not move quite so quickly between the rollers, which effects a slower rate of enlargement of the tube. When the enlargement to the slip-free point is reached, the displacing means can be immediately subjected to a pressure or counterpressure of the pressure medium so that the mandrel cannot move any further in relation to the rollers, with the result that the rollers cannot be spread any further apart. If the rotatable body is rotated for three or

four further revolutions, then the end of the rolling location is rounded out by the rollers with the full slip-free enlargement, which results in a very good fit at the rolling location. For release of the rollers, the rotatable body is rotated in the reverse direction, whereby the rollers are screwed out of the tube until the mandrel no longer holds the rollers in contact with the inside wall of the tube. The rollers and rotatable body can then be withdrawn from the tube.

It is also possible to carry out such a step at the start of an enlarging process, by holding the rollers and rolling until the slip-free enlargement is achieved without a pressure being present in the cylinder. After reaching the slip-free enlargement, the piston of the displacing means is again subjected to pressure loading at both sides thereof and rolling is continued. In that case, due to the inclined position of the rollers, the rotatable body moves further into the tube with simultaneous maintenance of the desired slip-free enlargement because the mandrel cannot be drawn further between the rollers due to its retention by the piston.

Examples of the method and embodiment of the apparatus according to the present invention will now be more particularly described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a schematic sectional view of apparatus according to one embodiment of the invention, and

Fig. 2 is a schematic sectional view of part of apparatus according to another embodiment of the invention.

Referring now to the drawings, in Fig.1 there is shown tube enlarging apparatus comprising a roller housing 11 with a front part 12 and a rear part 13. A roller body 15 is mounted in the housing to be freely rotatable in a needle roller bearing 16 by a flange 14 at the front end of the housing part 12. Distributed around the circumference of the body 15 are, for example, three slots 17, in which rollers (not illustrated) are arranged to extend parallel to the longitudinal axis of the body 15. A mandrel 18, which is axially displaceable into the rotatable body 15 to spread the rollers radially apart, is mounted to extend through a chamber 19 formed in the housing front part 12, the chamber 19 receiving air or oil coolant via an inlet 20. The length of the chamber 19 corresponds to the travel which the mandrel 18 must execute for the maximum spreading of the rollers.

The mandrel 18 is provided at its rear end with a rectangular-section shank 21 secured to an extension 22 of a piston-cylinder unit, the extension 22 being sealingly mounted in a wall 23 of the housing 11. The extension 22 is connected to a piston 24 slidably engaged in a cylinder 25 in the rear part 13 of the housing 11. A rod 26 is connected to the piston 24, is guided through an end wall 27 of the cylinder 25 and is coupled to a rotary drive (not shown), a telescope guidance being provided. The piston 24 is displaceable between two abutments 28 and 29 in the cylinder 25 and a respective feed duct 30 or 31 for hydraulic fluid is provided in each of these abutments. A hydraulic pump supplies fluid to the ducts.

In operation of the apparatus to enlarge a tube for pressure fitting in an opening in a support, the body 15 is at first inserted into the tube until the tube abuts an abutment 32, the mandrel 18 and piston 24 having the setting illustrated in the drawing, while the rotary drive turns the mandrel 18. Pressure is now exerted on the piston 24 by hydraulic fluid applied through the ducts 30, the pressure being relatively low but a relatively large quantity of the fluid being supplied. As a result, the rolling mandrel 18 is moved forwardly relatively quickly between the rollers. When torque builds up at the interface of the rollers and mandrel 18, the hydraulic pump is switched over to high pressure supply, whereby a slower rolling mandrel advance is obtained. This slow advance of the mandrel 18, through which the actual enlargement of the tube is effected, can be set, limited and, if so desired, controlled in dependence on the tube dimensions, material and wall thickness, and the speed of the rotary drive. When enlargement of the tube to the point of slip-free engagement with the support has been reached, as determined by a control device controlling pumping of the pressure fluid, then the supply of the fluid is set so that it maintains the pressure required for this degree of enlargement, while the rotary drive continues to run. As a result, a good rounding-out of the end of the rolling location is obtained and the rolling location itself is absolutely cylindrical, which is extremely important for, in particular, tubes with small wall thicknesses.

It is possible to perform the rounding-out process with the rotary drive running in the opposite direction. In either case, the time during which rounding-out is carried out is settable by the operator.

For releasing the roller body 15 from the tube, pressure fluid is exhausted through the duct 30 and applied through the duct 31. As a result, the piston is guided back into the initial position illustrated in the drawing and the apparatus is ready for a further rolling operation.

When the rollers extend obliquely in the rotatable body, then the mandrel 18 is automatically drawn between the rollers and spreads these until the preset point of slip-free enlargement is reached. At this instant, pressure fluid is applied by the hydraulic pump through the duct 31 to the piston 24 and so holds the piston and thereby the mandrel 18 firmly in the position concerned that, with the rotary drive running, the rollers cannot draw the mandrel further therebetween. This allows the rolling location to be rounded out. When the rotary drive, after attainment of the slip-free enlargement, is changed over to reverse rotation, then such a pressure must be applied to the piston 24 by way of fluid fed through the duct 30 that the mandrel

in its position corresponding to the slip-free enlargement is firmly retained in relation to the rollers. The control of these types of processes is known and can be effected by known means.

If the mandrel 18 is not be be drawn between the rollers at the speed predetermined thereby, then there must be built up in the cylinder 25 a pressure which is smaller than the force with which the mandrel 18 is drawn between the rollers. This can also be effected by a suitable counter-pressure.

In Fig. 2 there is shown part of tube rolling apparatus comprising a piston 32 arranged in a cylinder 33, a mandrel 34 being rotatably mounted but sealed off in the piston 32. The mandrel 34 has a flange 35 bearing against a needle roller bearing 36, which is arranged in the piston 32. The section 37 of the mandrel passing through the piston is sealed from the piston by a seal 38, for example a retaining ring. A flange 39 of a drive shaft 40 receives the end portion of the section 37 projecting out of the piston 32 and is secured to the end portion 40 by a transversely extending pin 41. The flange 39 bears against a needle roller bearing 42 in the piston 32. The piston itself is tightly fitted by means of a seal 44 in a cylinder housing 33. The shaft 40 is sealed off by seals 43 in the housing bore.

It will be appreciated that other embodiments of the apparatus are possible with the scope of the invention as defined in the appended claims. Thus the hydraulic cylinder — or a pneumatic cylinder — could be provided with a piston arranged adjacent to the mandrel extension in the apparatus housing or otherwise adjacent to the housing and transmit thrust to the mandrel through, for example, a fork.

CLAIMS

1. A method of enlarging a tube for pressure fitting in an opening in a support, comprising the steps of introducing into such tube a plurality of rollers carried by a rotatable body, applying a pressure medium to piston-cylinder displacing means to effect movement of an operatively associated conically tapering mandrel between the rollers to spread the rollers radially apart, and controlling the application of the pressure medium in dependence on the reaction force acting on the mandrel during rotation of the body to deform the tube by the rollers.

2. A method as claimed in claim 1, wherein the axes of the rollers extend parallel to the tube axis and the step of controlling comprises causing the pressure of the pressure medium applied to the displacing means to be greater than said reaction force.

3. A method as claimed in claim 2, wherein the step of controlling comprises causing the pressure of the pressure medium applied to the displacing means to be substantially equal to the reaction force for a selectable period of time occurring before enlargement of the tube by the rollers to the point of slip-free interengagement of the tube and support.

4. A method as claimed in either claim 2 or claim 3, wherein the step of controlling comprises causing the pressure of the pressure medium applied to the displacing means to be substantially equal to the reaction force for a selectable period of time occurring after enlargement of the tube by the rollers to the point of non-slip interengagement of the tube and support.

5. A method as claimed in claim 1, wherein the axes of the rollers so extend obliquely relative to the tube axis that the rollers exert a force on the mandrel tending to draw the mandrel between the rollers and the step of controlling comprises causing the pressure of the pressure medium applied to the displacing means to be smaller than said force exerted by the rollers on the mandrel.

6. A method as claimed in claim 5, wherein the step of controlling comprises causing the pressure of the pressure medium applied to the displacing means to be substantially equal to said exerted force for a selectable period of time occurring before enlargement of the tube by the rollers to the point of non-slip interengagement of the tube and support.

7. A method as claimed in either claim 5 or claim 6, wherein the step of controlling comprises causing the pressure of the pressure medium applied to the displacing means to be substantially equal to said exerted force for a selectable period of time occurring after enlargement of the tube by the rollers to the point of non-slip interengagement of the tube and support.

8. A method of enlarging a tube by rolling, substantially as hereinbefore described with reference to Fig. 1 or Fig. 3 of the accompanying drawings.

9. Apparatus for enlarging a tube for pressure fitting in an opening in a support, the apparatus comprising a plurality of tube-engaging rollers carried by a rotatable body, a conically tapering mandrel movable between the rollers to spread the rollers radially apart, and displacing means comprising a cylinder and a piston arranged in the cylinder and connected to the mandrel, the piston being so displaceable by a pressure medium applied to the cylinder as to effect said movement of the mandrel, and control means for controlling the application of the pressure medium in dependence on the reaction force acting on the mandrel during rotation of the body to deform the tube.

10. Apparatus as claimed in claim 9, wherein the cylinder is provided by part of a housing of the apparatus.

11. Apparatus as claimed in claim 9, wherein the cylinder is provided by a member arranged in or adjacent to a housing of the apparatus.

12. Apparatus as claimed in any one of claims 9 to 11, wherein the piston is double-acting, the cylinder being provided with inlet means for the pressure medium on each side of

the piston.

13. Apparatus for enlarging a tube for pressure fitting in an opening in a support, the apparatus being substantially as hereinbefore described with reference to either Fig. 1 or Fig. 2 of the accompanying drawings.

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